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EXHAUST MANIFOLD OF INTERNAL-COMBUSTION ENGINE JP S60-81420

What is claimed is:

An exhaust manifold of internal-combustion engine wherein the main body of the exhaust manifold has double-layered structure comprises,

an inner pipe unit made of ceramic fiber molded into multiple cylinders and
an aluminum outer pipe unit having similar shape with said inner pipe unit
wherein said outer pipe unit is integrally molded with said inner pipe unit.

Detailed Description of the Invention

(Technical field)

The present invention is related to an exhaust manifold of internal-combustion engine.

(Background of the invention and Prior Art)

It is well known that exhaust manifolds (multiple exhaust cylinders) are often connected to each cylinder in multicylindered internal-combustion engine for automobiles. It is also well known that the structure of the exhaust manifold is often designed so as to avoid adverse influence of heat in manufacturing and assembling or to save weight in manufacturing and assembling. For example, conventional exhaust manifolds are described in Japanese utility model application No. S56-37047 and Japanese utility model publication No. S57-47713. The exhaust manifold in the latter example (Japanese utility model publication) is shown in Figs. 1(A) and (B).

The main body of the exhaust manifold 1 has a double-layered pipe unit comprises an inner pipe unit 2, which is made of solid ceramic material and molded into multiple cylinders, and an outer pipe unit 2, which is made of cast iron and integrally molded with the inner pipe unit. The exhaust manifold is divided into three parts and lined column-wise to cylinders (tripartition structure).

Using the above-mentioned ceramic material drastically saves weight of the part (conventionally) made of heavy cast-iron, and saves the (total) weight of the exhaust manifold.

On the other hand, heat stress and vibration to the inner pipe unit 2 caused by driving or stopping engine and thermal shock caused by molding the main body of the exhaust manifold are effectively reduced by introducing the above mentioned tripartition structure. In other words, because the inner pipe unit 2 is made of inflexible solid ceramic material and the outer pipe unit 3 is made of cast-iron, which has a high melting point (the liquid temperature for forging cast-iron is from 1,500 to 1,600 ℃), the damage to the inner pipe unit 2 caused by the thermal shock in manufacturing the main body of the exhaust manifold and the heat stress caused by the difference of thermal expansion coefficient between the inner pipe unit 2 and the outer pipe unit 3 in assembling are prevented by the tripartition structure.

However, in the conventional exhaust manifold of internal-combustion engine, number of parts, man-hour and cost are increased because the exhaust manifold is designed to have tripartition structure in the longitudinal direction to avoid adverse influence of heat.

Further, because the solid ceramic, which is forming the inner pipe unit 2, has low porosity and has insufficient insulation (in other words, the temperature of the outer pipe unit 3 is relatively high) only heat- resistant materials can be used for the outer pipe unit 3. This is one of the crucial factors, which obstructs drastic weight saving by introducing right materials, such as aluminum.

(Purpose of the invention)

This invention is made especially focusing on solving the above-mentioned problems. The purpose of the invention is to reduce cost by introducing unitary construction and to save weight drastically by using aluminum.

(Framework and mechanism of the invention)

To achieve these goals, in the present invention, the main body of the exhaust manifold for multicylindered internal-combustion engine for automobiles is designed to have two layered structure comprising an inner pipe unit made of ceramic fiber molded into multiple cylinders and an aluminum outer pipe unit having similar shape with the inner pipe unit wherein the outer pipe unit is integrally molded with the inner pipe unit.

In the present invention, because the inner pipe unit, which is made of ceramic fiber and has low heat conductance, insulates the hot exhaust heat, the outer pipe unit may be made of aluminum material, which has low melting point.

Moreover, the inner pipe unit made of ceramic fiber is much more flexible than the conventional pipes made of solid ceramic, and as mentioned above, aluminum material has much lower melting point than cast-iron. (the liquid temperature for forging aluminum material is around 700 ℃). Therefore the inner pipe unit suffers very little heat stress in forging and has less possibility to be damaged. It also makes it possible to form the exhaust manifold into unitary construction and reduces cost.

(Embodiments)

First embodiment of the present invention is described referring to the drawings. As shown in Figs 2(A), (B) and (C), all cylinders of the main body of the exhaust manifold 10 is unitary constructed.

Further, the main body of the exhaust manifold 10 has a two layered structure comprises the inner pipe unit 11 and the outer pipe unit 12.

The above mentioned inner pipe unit 11 is made of ceramic fiber and is molded into multiple cylinders, and the outer pipe unit 12 is made of aluminum wherein the outer pipe unit 11 is integrally molded with the inner pipe unit.

The ceramic fiber materials available for the inner pipe unit 11 are silica alumina fiber, alumina fiber and silica fiber and so on.

Example characteristics of the materials are shown in the following table. These cast materials have high strength and rigidity, as they are distinct with their bend strength, and they are totally different from flocculent fiber.

Item	Description
Bulk density	0.2~0.7 gram/cm^3
Melting point	1800℃
Bend strength	5~15 kg/cm^2
Component	
Al_2O_3	40~60%(weight)
SiO_2	60~40%(weight)

Either wet lamination or vacuum forming is adopted to produce halved or entire unit of the inner pipe unit 11.

Wet lamination is a casting method in which the several thin ceramic fiber sheets absorbing the binder, such as silica solution are layered.

Vacuum forming is a casting method in which the (shaped) wire fabric is soaked into the solution including floating ceramic fiber and then vacuumed.

Meanwhile, the vacuum forming has an advantage in that the surface facing to the wire fabric, in other words the surface facing to emission gas, has high density, has high resistance to emission gas, and prevents flaking of the fiber. At the same time, the joint part to the aluminum outer pipe unit 12 is soft in some degree and has high heat resistance. On the other hand, in wet lamination, density of whole ceramic is even, and the ceramic has higher resistance.

In the present invention, aluminum liquid is used for forging the main body of the exhaust manifold (the outer pipe unit 12). Because the temperature of the aluminum liquid is around 700℃ and considerably lower than conventional forging liquids, difference of temperatures between the outer pipe unit 12 and the inner pipe unit 11 is reduced by half. Moreover, because the inner pipe unit 11 is made of ceramic fiber, which is considerably more flexible than conventional solid ceramics, the heat stress to the inner pipe unit 11 is reduced and the damage to the inner pipe unit 11 can be avoided. In other words, unitary construction in the present invention makes it possible to reduce number of parts, man-hour and cost for manufacturing and assembly.

Following table shows the difference of temperature limits to protect against the failures caused by thermal shock to the popular solid ceramics.

Name of material	Temperature limit
Silicon nitride (Si_3N_4)	500℃
Silicon carbide (SiC)	280℃
Zirconia (ZrO_2)	260℃
Ceramic fiber	Higher than 1000℃

Moreover, in the present invention, because the inner pipe unit 11 is made of ceramic fiber and its thermal conductivity is lower than conventional solid ceramics, the emission gas is not cooled down, and the gas cleanup efficiency by a catalytic substance, which is placed in the emission, is increased. On the other hand, because the ceramic fiber prevents the rise of temperature, it also makes it possible to use aluminum materials, which have low melting point, for the outer pipe unit 12.

Meanwhile, following tables show the thermal conductivity of ceramics and air, as a control, and the difference of the temperature of interface between the inner pipe unit 11 and the outer pipe unit 12 in the main body of the exhaust manifold when an engine is running under very high·load conditions. (temperature of the emission gas is from 750 to 850℃).

Name of material	Thermal conductivity *
Silicon nitride (Si_3N_4)	0.037
Silicon carbide (SiC)	0.158
Ceramic fiber	0.0001
Air	0.00006

(*unit: calorie/cm·sec·℃)

Spec	Temperature of intersurface
The present invention (Ceramic fiber)	250~350℃
Conventional (Solid ceramic)	550~650℃

Because aluminum material is available for the outer pipe unit 12, the weight of the main body of the exhaust manifold is drastically saved compared to the one made of iron-cast in conventional examples, and the total weight of the engine is also reduced.

Fig. 3 describes the second embodiment of the present invention. A coating layer 13 (ceramic fiber hardened layer) is applied to the inner surface of the inner pipe unit 11 to avoid wearing and dispersing of fibers by long time running. In fact, because the ceramic fiber, which is forming the inner pipe unit 11, has lower density than conventional solid ceramics, fibers (in the surface) may be fell out because of the repeated heat stress, pulsating pressure, or oscillation in long time use. The above-mentioned coating layer 13 prevents these damages.

Meanwhile, the coating layer 13 is applied by dipping coating using the silica solution or by plasma coating using aluminum oxide (Al_2O_3). Thickness of the coating is adjusted by changing the density of the dipping solution and dipping time.

(Effect of the invention)

In the present invention, because the main body of the exhaust manifold is designed to have two-layered structure comprising the inner pipe unit made of ceramic fiber and the outer pipe unit made of aluminum, which has a same shape with the inner pipe unit and is integrally molded with the inner pipe unit, heat stress to the inner pipe unit in forging is reduced, unitary construction is available, man-power and cost in manufacturing and assembly are reduced, and weight is drastically saved.

Moreover, because insulation effect of the inner pipe unit is high, temperature drop of the emission gas is reduced, and the gas cleanup efficiency is increased.

(Brief explanation of the drawing)

Fig. 1 (A) is a front view of an example of conventional exhaust manifolds.
Fig. 1 (B) is a cross-sectional view of the same taken along the line I-I.
Fig. 2 (A) is a front view of the first embodiment of the present invention.
Fig. 2 (B) is a cross-sectional view of the same taken along the line II-II.
Fig. 2 (C) is a cross-sectional view of the same taken along the line III-III.
Fig. 3 is a cross-sectional view of the second embodiment of the present invention taken along the same line as Fig. 2 (C).

10: main body of exhaust manifold
11: inner pipe unit
12: outer pipe unit
13: coating layer